COLORADO WATER CONSERVATION BOARD

ALERNATIVE AGRICULTURAL WATER TRANSFER METHODS COMPETITIVE GRANT PROGRAM

GRANT APPLICATION FORM

Implementation of Deficit Irrigation Regimes: Demonstration and Outreach	**South Platte**
Program/Project Name	**River Basin Name**

$154,734	$20,000
Amount of Funds Requested	Amount of Matching Funds

Instructions: This application form must be submitted in electronic format (Microsoft Word or Original PDF). The application can be emailed or a disc can be mailed to the address at the end of the application form. The Alternative Agricultural Water Transfer Methods Competitive Grant Program, Criteria and Guidelines can be found at http://cwcb.state.co.us/LoansGrants/alternative-agricultural-water-transfer-methods-grants/Pages/main.aspx. **The criteria and guidelines must be reviewed and followed when completing this application**. You may attach additional sheets as necessary to fully answer any question, or to provide additional information that you feel would be helpful in evaluating this application. Include with your application a cover letter summarizing your request for a grant. If you have difficulty with any part of the application, contact Todd Doherty of the Water Supply Planning Section (Colorado Water Conservation Board) for assistance, at (303) 866-3441 x3210 or email at todd.doherty@state.co.us.

Generally, the applicant is also the prospective owner and sponsor of the proposed program/project. If this is not the case, contact Todd before completing this application.

Alternative Agricultural Water Transfer Methods – Grant Application Form
October 2010

Part A. - Description of the Applicant(s) (Program/Project Sponsor);

1. Applicant Name(s): Colorado State University

Mailing address:
Office of Sponsored Programs
2002 Campus Delivery
200 West Lake Street
Fort Collins, Colorado 80523-2002

Taxpayer ID#: 846000545

Email address: Linda.Loing@ColoState.edu

Phone Numbers: Business: 970-491-6586

Home:

Fax: 970-491-6147

3. If the Contracting Entity is different then the Applicant, please describe the Contracting Entity here.

4. Provide a brief description of your organization. The applicant may be a public or private entity. Given the diverse range of potential applicants, not all of the following information may be relevant. Where applicable and relevant the description should include the following:

   Founded in 1870 as the Colorado Agricultural College, CSU is the home to one of the strongest community-service programs in the country. For the past 100 years, CSU Extension has been helping Coloradoans with some of their most challenging issues. As a result of CSU Extension partnership with eXtension.org, everyone with a computer can access an extensive network of experts who can assist with their day-to-today questions. An important example of CSU Extension activities is the development of guidelines to help Colorado crop producers to employ BMPs that protect the state's water resources while allowing producers to remain economically competitive.

Part B. - Description of the Alternative Water Transfer Program/Project –

1. Purpose of the Program/Project

Among the available Alternative Agricultural Water Transfer Methods (ATMs), deficit irrigation is one that if successfully implemented, can offer significant benefits to both agricultural and M&I users. However, deficit irrigation practices require accurate water management to achieve increased water productivity (more crop per drop), and accurate documentation of consumptive use to meet state regulations and maintain historical return flows. Numerous research studies have been conducted in the past aimed to develop a wide variety of techniques for managing irrigations and documenting water balance components under deficit irrigation regimes. While some of these techniques can be used in practical applications of deficit irrigation, most are complicated and/or data-intensive and their application will likely remain limited to research studies. This proposal aligns with the recommendations stipulated in the CWCB Technical Memorandum entitled "Alternative Agricultural Water Transfer Methods Grants Program Summary and Status Update" of November 2012. In particular this proposal aligns with the second recommendation in section 1.3.1 South Platte Basin, page 6, of the report that refers to supporting "demonstration/pilot projects to determine the feasibility of new concepts or techniques as needed". In addition, we believe that transferring technology and educating water users and regulators on different aspects of implementing a technically and economically feasible deficit irrigation program will be determinant toward the adoption of this practice as a viable and mutually-beneficial ATM. The importance of training water users is also emphasized in the November 2012 report (section 2.2, page 10), as the project completion report by the Colorado Corn Growers Association "recommends that the CWCB produce educational materials that would assist a lay person with understanding water transfers."

The specific goals of the proposed demonstration and outreach project are:

- To demonstrate the feasibility (technical and economic) and resource-requirement of using selected water management techniques to quantify the water balance components and consumptive use under different deficit irrigation levels, on crops such as corn and sunflower, on clayey to sandy soil types, with pressurized and surface irrigation methods, and under different agronomic practices. Technical feasibility involves a practical, cost-effective monitoring approach and economic feasibility involves understanding and demonstrating crop water productivity, production costs and farmer incentives. Numerous sensors and their related equipment (e.g., infra-red thermometers, dataloggers, neutron probe, multispectral scanner, etc.) required to achieve this goal will be provided by CSU.
- To educate and train water users and regulators about using these techniques and their advantages and disadvantages (including limitations) through a variety of outreach and extension activities, such as publishing online and printed manuals including user-friendly spreadsheets, fact sheets, newsletters, and magazine articles; holding field days and a training workshop (video recordings to be made available online); and, creating a YouTube channel to upload short informational video clips.

This project will build upon the results of previous studies to demonstrate, transfer technology and educate on how some of the most promising techniques can be used, with minimal instrumentation, to document water balance components under deficit irrigation regimes. One example of previous studies is the research conducted by Taghvaeian et al. (2012) in the Lower South Platte Project Research farm near Iliff, Colorado. The funding was provided, from 2010 to 2012, by Colorado Water Conservation Board to Parker Water and Sanitation District. In this project CSU was a partner that participated in several tasks. Specifically the title of

the project was "Lower South Platte Irrigation Research and Demonstration Project." We were directly responsible for Task 1 "to develop a practical means of calculating and verifying consumptive water use and water savings in alternative systems that will satisfy water court requirements." In Task 1B of this study, a relatively simple and empirical approach, based on crop canopy temperature, air temperature and relative humidity, was implemented and calibrated to estimate corn water stress (CWS) levels and posteriorly, along with reference evapotranspiration (ET_{ref}, computed using weather data) the crop water use was determined under deficit irrigation management. Results from the application of the CWS approach indicated that crop water use (or ET), values were accurate when compared with ET values estimated using a complex land surface energy balance model. In addition, Taghvaeian et al. (2013) conducted a similar study in the Limited Irrigation Research Farm (LIRF) near Greeley, Colorado and showed that the same approach could be used with minimum instrumentation to quantify water stress and water use for corn under deficit irrigation.

2. Study Area/Service Area Description

Four sites will be used for demonstration and training purposes of this project within the South Platte River Basin Area:

a) The first site is the Limited Irrigation Research Farm (LIRF), which is located close to the city of Greeley, Colorado. This site is operated and managed by the USDA ARS Water Management Research (WMR) Unit. The predominant soil type is Olney fine sandy Loam. Grain corn and sunflower will be planted at this site under 12 different levels of irrigation applications, ranging from full irrigation (100%) to providing only 40% of the water requirement during different stages of growth. The irrigation is provided using a pressurized drip system. Yield monitoring will be performed by the WMR and the data will be used to evaluate water productivity (yield/water used) of different deficit irrigation treatments.

b) The second site is located within the LIRF limits. The time and effort required as well as the machinery and equipment needed to manage this site will be provided by the Northern Water personnel as in-kind contribution to this proposal. The site will be planted to corn while the irrigation will be a surface or gravity irrigation system. A similar deficit irrigation scheme as the ARS fields will be adopted. Different agronomic practices (e.g. twin-row vs. single row planting) and their effect on corn water use and yield will be demonstrated at this site. Previous experiments at this site have revealed that agronomic practices can have a significant effect on crop water stress productivity under deficit irrigation, mainly due to decreased competition among individual plants. Figure 1 depicts the location of the Greeley sites. A CoAgMet weather station (Greeley 4) is within the limits of these sites.

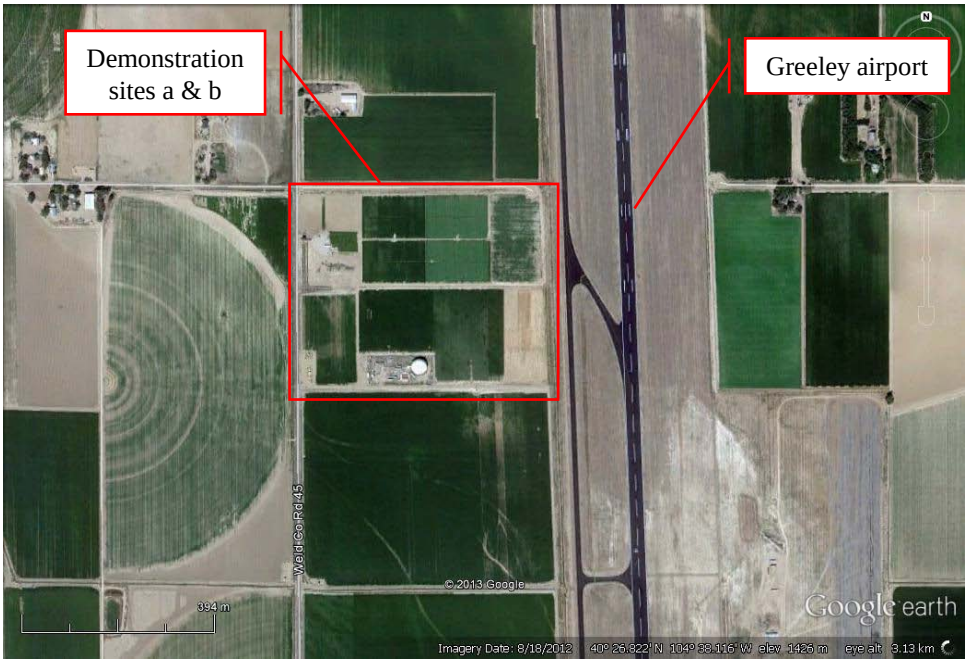

Figure 1. Location of LIRF demonstration sites, drip irrigation and surface irrigation fields.

c) The third site is the CSU Agricultural Research Development and Education Center (ARDEC), field 3100, located north of Fort Collins, Colorado. In this field, a new center pivot, capable of variable rate irrigation (VRI) that uses speed and nozzle control, was installed in 2012. The system irrigates approximately 18 acres. The soil texture type is Kim loam and Nunn clay loam. Figure 2 shows the location of the ARDEC demonstration site.

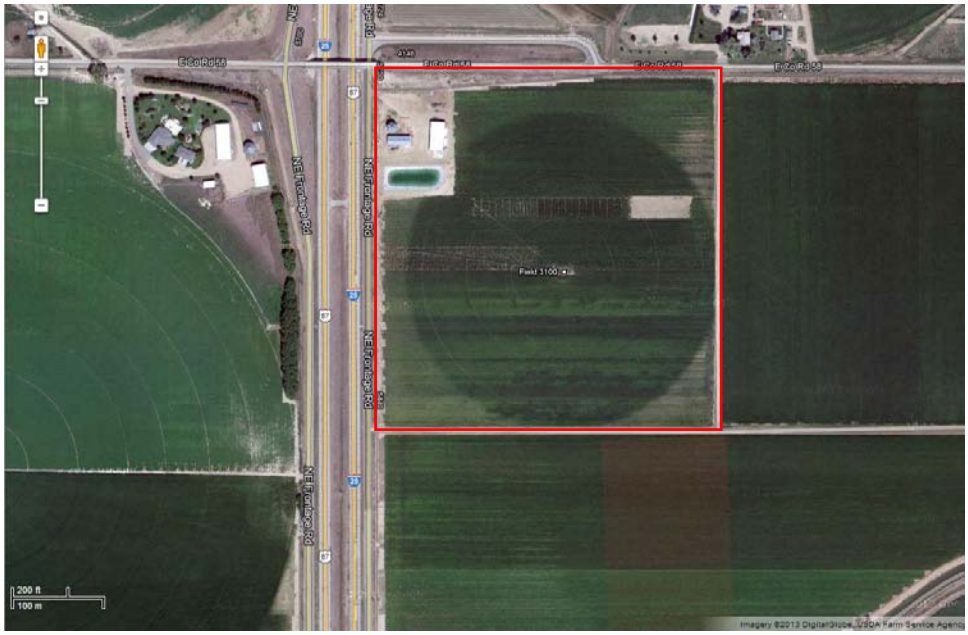

Figure 2. Location of ARDEC demonstration site, center pivot.

Corn will be planted in this field and irrigation plots will include full irrigation (to meet 100% of the crop consumptive water use or ET), deficit irrigation levels at 80%, 60% and 40% of corn ET. In addition a non-irrigated plot will be included as well. There will be three replications of each irrigation level.

d) Site four is located near La Salle, CO. This field is a center pivot (Figure 3) site managed by a Central Colorado Water Conservancy District (CCWCD) farmer. The soil type is a loamy sand soil. The system irrigates 95 acres of alfalfa. Similarly, different levels of deficit irrigation amounts will be implemented and monitored with the proposed techniques. A second limited irrigation center pivot field will be identified, managed by a farmer, and preferably planted to corn.

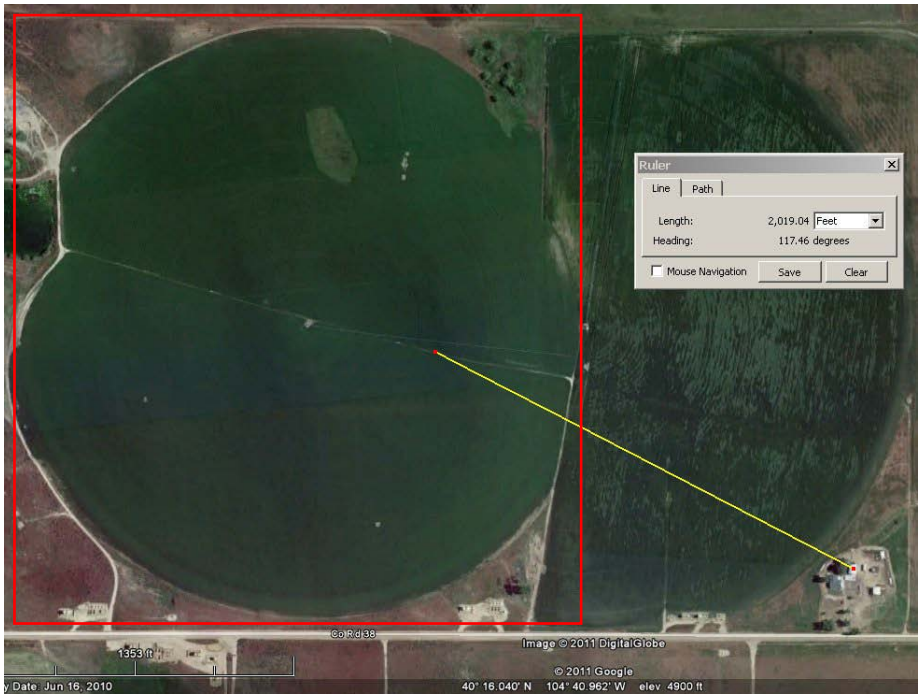

Figure 3. Line of sight for the wireless transmission of soil moisture data from the datalogger in the field (Randy Ray's) to the receiving antenna/computer housed in a shed near La Salle, CO.

3. Description of the Alternative Water Transfer Method

   The type of water transfers that will be implemented is the reduced consumptive use through deficit irrigation and agronomic practices. The transferable consumptive use will be quantified, using several available techniques that are explained in detail in section 5. The information on actual and salvaged consumptive use will be further analyzed in conjunction with irrigation application data (measurements) to document the return flows.

4. Program/Project Eligibility

   Please describe how the proposed program/project meets each of the following eligibility requirements (please see Criteria and Guidelines for additional information regarding the alternative water transfer methods/strategies that qualify for funding). Note: If these requirements are addressed in other parts of the application you may simply reference the applicable section(s).

   a) A description of how, if implemented, the proposed program/project will protect property and water rights.

      Deficit irrigation changes historic irrigation practices and return flows. This Project will develop a reliable and practical monitoring system to document the saved CU under deficit and the impact on return flows from the water balance analysis. The essential element of any transfer is quantifying CU and the augmentation requirement to maintain return flows for the protection of others water rights and that is the main objective of this Project.

   b) Identified group(s) of agricultural users that are or may be willing to transfer a portion of their water and identified entity(s), group(s) or area(s) where the transferred water could or would be put to the new use and a description of the new use.

      This proposal does not address this item.

   c) The program/project must at a minimum conceptually describe the technical, institutional, and legal elements of the water transfer. Grant monies may be used to address one or more of these elements. If grant monies are not requested for all three elements, the grant applicant must describe how the applicant has or intends to address the elements, which are not included in the grant request, through other efforts.

      This project addresses the technical element of water transfer. This is done by monitoring and documenting deficit irrigation through different methods that vary in complexity and associated cost.

   d) If grant monies are proposed for use for legal assistance then the use of those funds shall be oriented toward advancing the knowledge of alternative agricultural water transfer methods and techniques; not for preparation of a specific water court case. The total requested funds for legal assistance shall not exceed 40 percent of the total grant request. In addition, grant monies proposed for use for legal assistance must be used to collaboratively address issues and concerns related to agricultural water

transfer. Funds shall not be used to solely advance the cause of the project proponents.

This project does not request funds for legal assistance.

e) A minimum of a 10 percent cash match of total project cost (past expenditures and "in kind" can not be counted toward the 10 percent match).

The minimum of 10% cash match requirement is satisfied through funds committed by collaborators as CCWCD, Northern Water, and the USDA ARS WMR.

5. Program/Project Evaluation Criteria

The following grant evaluation criteria will be used by the CWCB to evaluate and make recommendations to fund, partially fund or not fund a grant application. The criteria are aimed at advancing alternative transfer methods from the literature and studies to actual on the ground projects/programs that provide reliable water supply and sustain key elements of the agricultural area from which the water is transferred. The applicant should fully address and explain in detail in the application how, and the extent to which, the proposed project/program meets each of the criteria. However, it should be noted that the project does not have to meet all of the criteria to be eligible to receive funding and the criteria below are not listed in any order of important or priority.

a. The proposed project/program builds upon the work of former alternative water transfer methods efforts and addresses key areas that have been identified. For more detailed information on this work, please refer to the draft report: *Alternative Agricultural Water Transfer Methods Grant Program Summary and Status Update*, November 2012.
Response: This proposal builds on the efforts and results obtained during the 2010-2012 project entitled "Lower South Platte Irrigation Research and Demonstration Project." In this project, it was established that soil water balance and monitoring crop water use utilizing relatively simple thermal-based sensors and weather data can provide accurate estimates of crop water stress and water use. Therefore, this project is a natural extension of such efforts in that technology transfer and education opportunities are sought.

b. The proposed project addresses one or more key recommendation(s) in the report: *Alternative Agricultural Water Transfer Methods Grant Program Summary and Status Update*, November 2012.
Response: This proposal aligns with the second recommendation in section 1.3.1 South Platte Basin, page 6, of the report that refers to supporting "demonstration/pilot projects to determine the feasibility of new concepts or techniques as needed."

c. Preference will be given to projects that provide additional matching resources in the form of cash, past expenditures and in-kind contributions that are in addition to the required 10% cash match.
Response: This project provides a cash matching (cost share) that satisfies the 10% minimum required. In addition the in-kind contributions include instrumentation (neutron probe sensor, infra-red

thermometers and loggers, multispectral radiometer, processing software, and time (effort) and expertise from collaborators. Past expenditures include those incurred during the 2010-2012 "Lower South Platte Irrigation Research and Demonstration Project."

d. The proposed project/program has the ability/potential to produce a reliable water supply that can be administered by the State of Colorado, Division of Water Resources.
   Response: Savings in crop consumptive water use through the practice of deficit irrigation can potentially provide a reliable water supply for M&I uses. This project will demonstrate practical techniques to quantify consumptive use savings from deficit irrigation. These techniques can help DWR administer the amounts of transfers from agricultural to M&I uses.
e. The proposed project/program produces information that is transferable and transparent to other users and other areas of the state (i.e., would provide an example "template" or roadmap to others wishing to explore alternate transfer methods).
   Response: The proposed project does produce information that is transferable and transparent to other users and other areas of the state. Guidelines for the implementation of the proposed monitoring of crop water use will be produced, along with spreadsheets (and extension literature) that will facilitate the computation and interpretation of the data collected.
f. The proposed project/program addresses key water needs identified in SWSI 2010 or as identified in a basin's needs assessment.
   Response: Yes, the project addresses keeping the farms in business through the implementation of deficit irrigation and the encouragement to transfer consumptive water use saved under this irrigation water management. The monitoring of crop water use techniques herein proposed will allow for the documentation of saved consumptive use.
g. The proposed project/program advances the preservation of high value agricultural lands. Value can be viewed as: the value of crops produced, the value the agriculture provides to the local community, and the value the agricultural area provides for open space and wildlife habitat.
   Response: The proposed project will constitute a tool that if implemented will help in the preservation of prime agricultural lands and the sustainability of irrigated agriculture.
h. The proposed project/program addresses water quality, or provides other environmental benefits to rivers, streams and wetlands.
   Response: The proposed project does not address water quality. However, the practice of deficit irrigation has the potential to reduce over-irrigation and non-point source pollution from agricultural chemicals and nutrients.
i. The proposed project/program increases our understanding of and quantifies program/project costs. This could include: institutional, legal, technical costs, and third party impacts.
   Response: The proposed project does address costs involved in implementing a given water management strategy or method. A spreadsheet will be created for this purpose.
j. The proposed project/program does not adversely affect access to other sources of water (not subject to/participating in the program) where owners of these water rights may wish to pursue traditional transfer of their rights to other users.
   Response: Yes, it does not affect access to other sources of water.
k. The proposed project/program provides a perpetual water supply for the new and/or alternate use and preserves agricultural production and/or helps sustain the area's economy from which the transfer is occurring.

Response: It does not guarantee a perpetual water supply. However, if a farmer has his/her water right limited or if he/she wants to monitor a deficit irrigation scheme for water use transfer then the tools derived from this project will be useful for that purpose through the monitoring of adopted schemes throughout the crop growing season.

l. The quantity of water produced by the proposed project/program. Preference will be given to programs that can address larger water supply needs.
Response: This project does not address this subject.

m. Applicants are encouraged to develop projects demonstrating participation and/or support from a diverse set of stakeholders and interests.
Response: This project involves collaboration among two irrigation districts (CCWCD and NCWCD or NW), one nationally recognized research and demonstration facility (USDA ARS WMR) and CSU research and extension personnel.

Statement of Work

WATER ACTIVITY NAME:
Implementation of Deficit Irrigation Regimes: Demonstration and Outreach

GRANT RECIPIENT:
Colorado State University

FUNDING SOURCE:
Colorado Water Conservation Board

INTRODUCTION AND BACKGROUND
This project is focused on implementing deficit irrigation regimes as a viable ATM. The project has demonstration and outreach components, proposed in response to findings and recommendations of previous work in this field. Some of these recommendations, as outlined in CWCB November 2012 report, include:

- Continue to support demonstration/pilot projects to determine the feasibility of new concepts or techniques as needed (section 1.3.1, page 6).
- Produce educational materials that would assist a lay person with understanding water transfers.

OBJECTIVES
The specific objectives of the proposed project are:

- To demonstrate the feasibility (technical and economic) and resource-requirement of using selected water management techniques to quantify the water balance components and consumptive use under different deficit irrigation levels, on crops such as corn and sunflower, on clayey to sandy soil types, with pressurized and surface irrigation methods, and under different agronomic practices. Technical feasibility involves a practical, cost-effective monitoring approach and economic feasibility involves understanding and demonstrating crop water productivity, production costs and farmer incentives.
- To educate and train water users and regulators about using these techniques and their advantages and disadvantages (including limitations) through a variety of outreach and extension activities, such as publishing online and printed manuals including user-friendly spreadsheets, fact sheets, newsletters, and magazine articles; holding field days and a training workshop (video recordings to be made available online); and, creating a YouTube channel to upload short informational video clips.

TASKS

TASK 1 – Demonstration

Description of Task

The demonstration component of this project will be carried out in collaboration with the Central Colorado Water Conservancy District (CCWCD), the Northern Colorado Water Conservancy District (Northern Water), and the USDA-ARS Water Management Research (WMR) Unit. Four available and proven techniques will be used to monitor water balance components (e.g., the reduction in crop consumptive use due to deficit irrigation and therefore potentially available for transfer to other uses), with the potential to be applied at field, farm, and ditch company levels. The feasibility and resource-requirement of each method will be evaluated for different crops, soil textures, irrigation methods, and agronomic practices. The demonstration sites will be located in the South Platte Basin, close to Greeley, La Salle, and Fort Collins (CSU ARDEC facility).

Method/Procedure and Deliverables

The following techniques will be used under this task.

Field level:

- Crop coefficient (K_c): This approach is suitable to estimate crop water requirement at different stages of growth. Under crop water stress conditions, a crop water stress coefficient (K_s) is used to reduce the potential crop water consumptive use ($ET_c = ET_{ref} \times K_c \times K_s$), computed from weather data, in proportion to the soil moisture deficit, where soil moisture deficit is modeled or measured. This method does not require complex modeling and the analysis can be performed in electronic spreadsheets (e.g. Microsoft Excel). A tool will be created and will be made available (along with a tutorial and manuals) through the internet (at the Colorado Water Institute and CSU Extension websites). Step-by-step explanation and hands-on experience will be also provided during a comprehensive workshop. The workshop will be coordinated and delivered with the participation of CSU Extension Water Team (e.g., Joel Schneekloth, Troy Bauder, Dr. Allan Andales, Dr. Reagan Waskom, and Dr. Luis Garcia).
- Canopy temperature (Tc): Previous studies have shown that canopy temperature is an effective indicator to determine crop water stress. Crop transpiration rate decreases as water becomes more limited in the root zone. Since transpiration is a major cooling process for plants, a decrease in the rate of this process translates into an increase in canopy temperature. By measuring canopy temperature, it is possible to quantify stress level, generate a crop water stress coefficient, and then calculate the transpiration rate using an estimate of reference evapotranspiration-ET (through weather data), all in a user-friendly spreadsheet format. This spreadsheet will integrate the Tc data obtained with the IRT sensor as well as the weather data from CoAgMet in an automated environment and will be made available to the public at no cost. Temperature measurements can be made using handheld Infra-red Thermometers (IRTs), which are now available at high accuracies and prices that are lower than most smart phones. In this demonstration project, three different handheld IRT models (varying in cost and sophistication) will be used to measure Tc on a biweekly basis. These IRTs include mobile and stationary units and will be all provided by CSU as in-kind contribution.

Ditch level:

- Landsat NDVI: Remote sensing images (multispectral) from satellites such as Landsat are processed by the USGS and made available to the public at no cost. Products such as the Normalized Difference Vegetation Index (NDVI) can be generated from these images by following a few simple steps. According to previous studies, NDVI can be directly related to crop coefficient. For example, Neale et al. (1989) conducted a comprehensive study between 1981 and 1986 at two sites near Greeley and Fruita, Colorado, and found that NDVI-based estimates can be used accurately to estimate corn Kc. The pixel size of NDVI images is less than 100 ft × 100 ft and temporal frequency of overpass is every 16 days, so they can be used to map water use over larger areas. The required analysis to generate NDVI maps and to convert them to distributed Kc is relatively simple and can be performed using open-source software packages that are available free of charge. A selected package will be made available to users (e.g., irrigation districts, water managers, etc.) along with a manual that describes the procedure and implementation steps.
- Landsat NDVI-surface temperature: NDVI images can be combined with Landsat surface radiometric temperature images to increase the accuracy of estimated water use. Compared to the NDVI method, the NDVI-surface temperature method requires a few more implementation steps. However, this method is still much simpler than other remote sensing methods and can be applied by a technician without the knowledge of solar radiation interaction with land surfaces. Landsat has a wide swath (115 miles). Therefore, a single image provides maps of Kc and consumptive use over large irrigated areas. This extensive spatial coverage makes the last two techniques appropriate for ditch level analysis. CSU engineering in cooperation with Northern Water is currently developing the ReSET (Remote Sensed ET) website for water user access that will show field-by-field computed ET from Landsat imagery and this platform could assist with the above ditch level analysis.
  A ground-based version of the NDVI product will be derived from data collected using a hand-held multispectral radiometer which has similar spectral bands as Landsat sensors. This product will serve as a verification of the quality of the Landsat product. Readings with the radiometer will be taken weekly to bi-weekly concurrently with IRT readings and neutron probe soil moisture readings on all fields and treatments/plots involved in the project.

The implementation practicability and functionality of each of the above methods will be determined by solving the root zone water balance, using soil moisture (volumetric water content). The water content data will be obtained using neutron scattering method, which is considered one of the most accurate methods of quantifying soil water content. Three to four access tubes will be installed at each field to a depth of 6 feet and soil water content readings will be taken on a bi-weekly basis using a neutron probe unit that will be made available to this project as an in-kind contribution. Comparing the neutron probe data with the results of each method provides an estimate of the reliability of each method, which will be evaluated in conjunction with the ease-of-application and resource-requirement to provide recommendations for their use in deficit irrigation implementation.

TASK 2 – Outreach

Description of Task

This project includes a strong outreach and extension component that will be implemented to disseminate information, to show results, and to educate water users on a successful implementation of deficit irrigation regimes as a viable ATM.

Method/Procedure and Deliverables

- *Field days*: One field day per year will be held at the demonstration sites indicated above to explain the effect of different deficit irrigation regimes on crop growth, as affected by varying soil textures and agronomic practices. The field days will most likely take place in July-August and they will be programmed for a period of 5-6 hours. Food and refreshments will be provided, along with printed material and talks on the barriers and potential of implementing deficit irrigation regimes. Efforts will be made to invite farmers, irrigation managers, state and federal agencies, etc. The CSU Extension Team will participate in talks.
- *Fact sheets*: fact sheets, articles in newsletters and magazines, as well as manuals on the technical and economic feasibility of the proposed techniques will be prepared and published. In addition, publications through this media and online will include managing deficit irrigation regimes and documenting consumptive water use (and resulting water savings due to reduced CU from deficit irrigation) on outlets such as the "Agricultural Water Conservation Clearinghouse" website of the Colorado Water Institute, CSU Extension website, as well as in printed format to be distributed among water users.
- *Spreadsheets*: User-friendly spreadsheets available through websites for computation of water use by Kc-Ks and Tc methods and for economic analysis of potential lease rates based on crop water productivity and production costs.
- *YouTube*: Educational short video clips will be created and uploaded to a YouTube channel. This will train viewers on different aspects of implementing deficit irrigation practices without requiring them to be present in the field.
- *Local conferences*: The outcome of this project will be presented to water users and farmers in general at local conferences such as the Central Plains Irrigation Conference/Expo, the High Plains No-Till Conference, and the Four States Irrigation Council Annual Meeting.
- *Training workshop*: A comprehensive one-day training workshop will be held at the end of this project (October-November of the second year) to provide participants with hands-on experience on how to use the utilized techniques for managing deficit irrigation regimes and for documenting water balance components. In addition, the workshop will include training on several methods to estimate and measure crop water use or ET. The workshop will be planned for 150 participants and it will be hosted at CSU. An instructive manual will be prepared and made available to the public along with the presentations and digital spreadsheets. Digital versions of the manual, presentations, spreadsheet tools, and a video of the workshop will be made available through the websites mentioned above. The CSU Water Team will help organize and deliver the workshop.

PROJECT MANAGEMENT PLAN

Each demonstration site will be managed independently to meet the specific requirements of that site, determined by the soil type, crop sensitivity to water stress, irrigation system, etc. Regular meetings will be held among all collaborators to communicate progress and limitations and to coordinate and plan

activities. These meeting will vary in frequency depending on the time of the year. More frequent meetings (every 2-3 weeks) will be held prior and during the growing season, while less frequent meetings (every 4-6 weeks) are required after the harvest.

REPORTING AND FINAL DELIVERABLE

Reporting: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of the executed contract. The progress report shall describe the completion or partial completion of the tasks identified in the statement of work including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Deliverable: At completion of the project, the applicant shall provide the CWCB a final report that summarizes the project and documents how the project was completed. This report may contain photographs, summaries of meetings and engineering reports/designs.

BUDGET

Total Project Costs (including 31.3% F&A)				
	Labor	**Other Direct**	**Matching Funds**	**Total**
Task 1 - Demonstration	*$58,001*	*$19,366*		*$77,367*
Task 2 - Outreach	*$58,001*	*$19,366*		*$77,367*
CWCB Contribution	**$116,002**	**$38,732**		**$154,735**
In-Kind Contributions			$20,000	$20,000
Total Costs:				**$174,735**

Project Personnel (fully burdened - includes fringe benefits and F&A)				
	PI	Post-doc		Total
hr/mo rate*	$98.90 / $17,143	$31.69 / $5492		
Task 1 - Demonstration	$8,571	$49,430		$58,001
Task 2 - Outreach	$8,571	$49,430		$58,001
Total Costs:	$17,143	$98,860		$116,002

*Colorado State University provides hourly labor rates for budgetary purposes only. Per OMB Circular A-21, Colorado State University tracks and reports personnel time based on percent of effort on a monthly basis.

Other Direct Costs (includes F&A)				
	Travel	Materials	Demonstration	Total
Task 1 - Demonstration	$7,510	$2,946	$8,909	$19,366
Task 2 - Outreach	$7,510	$2,946	$8,909	$19,366
Total Costs:	$15,021	$5,893	$17,819	$38,732

Total Project Costs (annually)							
	CWCB Contribution			CSU Cost Share			
PERSONNEL SALARIES	**Year 1**	**Year 2**	**Total Sponsor Contribution**	**Year 1**	**Year 2**	**Total Cost Share**	**Total Project Costs**
J. Chavez, PI, 0.5 month/yr	*5,171*	*5,378*	*10,549*	*0*	*0*	*0*	*10,549*
Fringe	*1,220*	*1,287*	*2,507*	*0*	*0*	*0*	*2,507*
S. Taghvaeian, Post-doc, 12 months, 6 months	*40,040*	*20,821*	*60,861*	*0*	*0*	*0*	*60,861*
Fringe	*9,449*	*4,983*	*14,432*	*0*	*0*	*0*	*14,432*
TOTAL SALARY:	45,211	26,199	*71,410*	0	0	*0*	*71,410*
TOTAL FRINGE:	10,669	6,270	*16,939*	0	0	*0*	*16,939*
TOTAL PERSONNEL:	**55,880**	**32,469**	**88,349**	**0**	**0**	0	88,349
DOMESTIC TRAVEL: PI and/or Post-doc travel: Multiple field trips to Greeley, La Salle, and ARDEC (north Fort Collins) for crop water use monitoring, workshop demonstrations; Local project related meetings and workshop organization; Colorado-based conferences (Four State Irrigation, CPIC, and High Plains No-Till). Costs include ground transportation, lodging, per diem, and registration fees.	**4,617**	**6,823**	**11,440**	**0**	**0**	0	11,440
MATERIALS AND SUPPLIES: Neutron probe access tubes and install; Lab consumables: tubes, cables, tapes, repair supplies	**3,916**	**572**	**4,488**	**0**	**0**	0	4,488
OTHER DIRECT: Field Days each year and Workshop in year 2. Costs include room/tent rental, video recording and editing, printed manuals, name badges, catering services, speaker ribbons, and brochures.	**4,137**	**9,434**	**13,571**	**0**	**0**	0	13,571
TOTAL DIRECT COSTS:	**68,550**	**49,298**	**117,848**	**0**	**0**	0	117,848
INDIRECT COSTS (F&A): 31.3% MTDC	**21,456**	**15,430**	**36,886**	**0**	**0**	0	36,886
Third-party Cost Share Commitments							
Central Colorado Water Conservancy District (CCWCD)				*5,000*	*5,000*	*10,000*	*10,000*
Northern Water (NCWCD)				*2,500*	*2,500*	*5,000*	*5,000*
USDA-ARS				*2,500*	*2,500*	*5,000*	*5,000*
TOTAL	**90,006**	**64,728**	***154,734***	**10,000**	**10,000**	**20,000**	***174,734***

SCHEDULE

The following is the proposed schedule for this project.

Task 1	2013		2014				2015	
	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q
Data collection								
Data processing and reduction								

Task 2	2013		2014				2015	
	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q
Field days								
Edu. materials								
Workshop								

PROJECT TEAM

The following is a list of personnel on this project.

Colorado State University:

- Dr. José L. Chávez (PI, Assistant Professor and Extension Irrigation Specialist, Department of Civil and Environmental Engineering and CSU Extension)
- Dr. Saleh Taghvaeian (Co-PI, Research Associate, Department of Civil and Environmental Engineering)
- Dr. Luis A. Garcia (collaborator, Department Head and Professor, Department of Civil and Environmental Engineering)
- Dr. Aymn Elhaddad (collaborator, Research Associate, Department of Civil and Environmental Engineering)
- Dr. Allan Andales (collaborator, Assistant Professor and Extension Irrigation Specialist, Department of Soil and Crop Sciences, CSU, and CSU Extension)
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- Dr. Raj Khosla (collaborator, Professor, Department of Soil and Crop Sciences, CSU))
- Mr. Troy Bauder (collaborator, Extension irrigation specialist, CSU Extension, Department of Soil and Crop Sciences)
- Mr. Erik Wardle (collaborator, Research Associate, Department of Soil and Crop Sciences)

Central Colorado Water Conservancy District

- Mr. Randy Ray (collaborator, Executive Director)

Northern Colorado Water Conservancy District

- Mr. Jon Altenhofen (collaborator, South Platte Projects Manager)

USDA-ARS Water Management Research Unit

- Dr. Tom Trout (collaborator, Research Leader)

PAYMENT

Payment will be made based on actual expenditures and invoicing by the applicant. Invoices from any other entity (i.e. subcontractors) cannot be processed by the State. The request for payment must include a description of the work accomplished by major task, and estimate of the percent completion for individual tasks and the entire water activity in relation to the percentage of budget spent, identification of any major issues and proposed or implemented corrective actions. The last 5 percent of the entire water activity budget will be withheld until final project/water activity documentation is completed. All products, data and information developed as a result of this grant must be provided to the CWCB in hard copy and electronic format as part of the project documentation. This information will in turn be made widely available to the public and help promote the development of alternative agricultural transfer methods.

Additional Information – If you would like to add any additional pertinent information please feel free to do so here.

The above statements are true to the best of my knowledge:

Signature of Applicant:

Print Applicant's Name: Linda Loing

Project Title: Research Administrator, Office of Sponsored Programs, Colorado State University

Return this application to:

Mr. Todd Doherty
Colorado Water Conservation Board
Water Supply Planning Section
1580 Logan Street, Suite 200
Denver, CO 80203
Todd.Doherty@state.co.us

REFERENCES

Neale CMU, Bausch WC, Heermann DF. Development of reflectance-based crop coefficients for corn. Trans. ASAE. **1989**; 32(6):1891-1899.

Taghvaeian S, Chávez JL, Hansen NC. Infrared Thermometry to Estimate Crop Water Stress Index and Water Use of Irrigated Maize in Northeastern Colorado. ***Remote Sensing***. **2012**; 4(11):3619-3637.

Taghvaeian S, Chávez JL, Altenhofen J, Bausch WC, DeJonge K, Trout T. Minimizing Instrumentation Requirement for Estimating Crop Water Stress Index and Transpiration of Maize. ***Irrigation Science***. **2013**; (Submitted, under review).